

Simulation of ratio of old to young people in countries like Poland

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Abstract

Countries like Poland with a recent sharp drop in birth rates still have some time to prepare for the problems of an ageing society. After the year 2030 they can become increasingly serious.

Retirement gets difficult to support if everybody lives longer, the birth rates go down, and retirement age and immigration/emigration remain constant. This demographic change influences the ratio of people in retirement age to those of working age. These effects have been simulated by statistical offices in many countries, but also with detailed assumptions in journals and a book [1, 2, 3, 4, 5]; the latter two references give a complete Fortran program.

These methods, with minor adjustments, were used to predict the future growth of this ratio for countries with low birth rates like Germany [1, 2, 6], intermediate birth rates like Algeria, [3] and high birth rates like the Palestinian territories [5], always ignoring special historical events which are particular for this country. Now we apply this method to a country like Poland where massive immigration may be less realistic; instead we simulate increases of birth rate and retirement age. Simulation details are shifted to an appendix.

The decay of the birth rate (more precisely, the average number of children per women, unfortunately called the total fertility rate) came in Poland later but sharper than in Germany and is approximated by $2.3 - 0.55 * [1 + \tanh(0.15(\text{year} - 1993))]$, Fig.1. The total simulated population, normalized by the actual Polish population in 2002, agrees well with what the official Polish authority, www.stat.gov.pl, predicted: Fig.2. Fig.3 shows the ratio of people above retirement age of 63 to the people between 20 and retirement age (lower curve). (Our time units are years throughout.)

The future looks less problematic if the number of people up to age 20 is added to those above 63, both groups needing public support. Then the ratio is approaching a minimum: middle curve in Fig.3. Thus for some time, according to Fig.3 until about 2030, the fraction of people needing support from the working population will not be much higher than it was in the past. Thus one has some years time to think, discuss and agree on how to solve the future problems of demographic change. The upper curve there shows the effects of a net emigration of 0.1 percent per year, starting in 2010 (e.g. from Poland to Western Europe; some statistical data give higher values already now). In

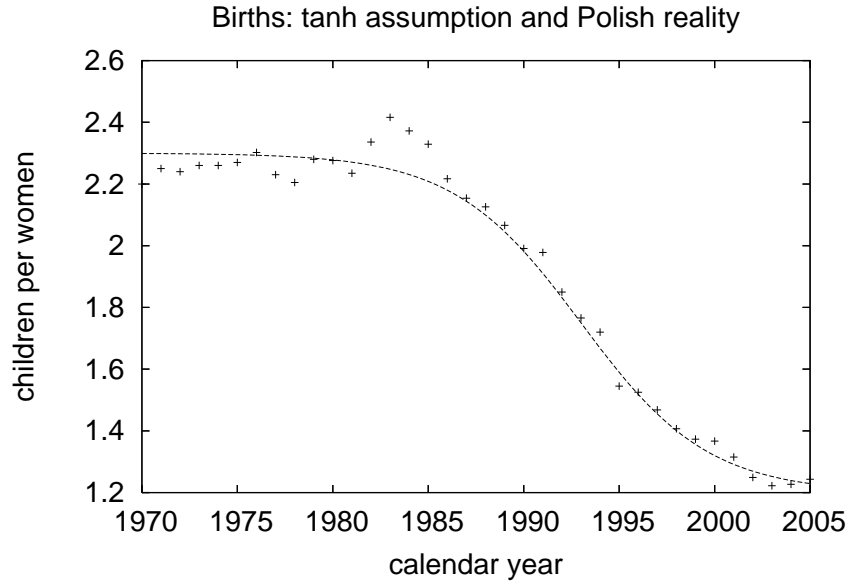


Figure 1: Real and assumed births. The + come from the official Polish statistics, the line is the tanh approximation used in the present simulations.

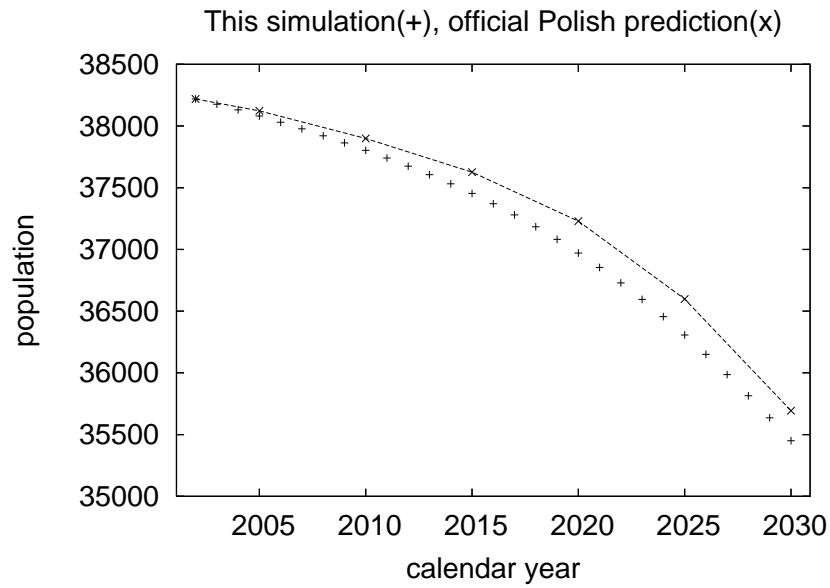


Figure 2: Official (line) and present (+ symbols) extrapolations of Polish population.

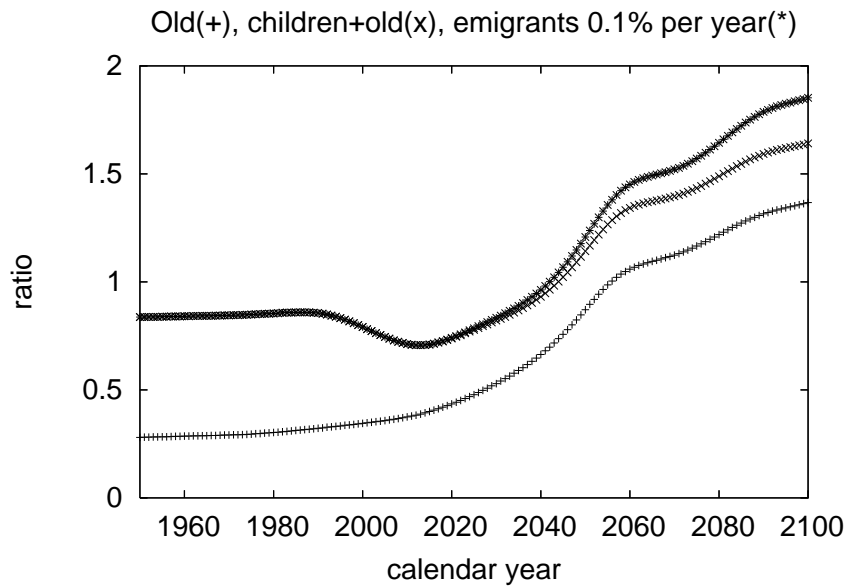


Figure 3: Ratio of old to working-age people. For the two upper curves the young people were added to the old ones. Border ages are 20 and 63.

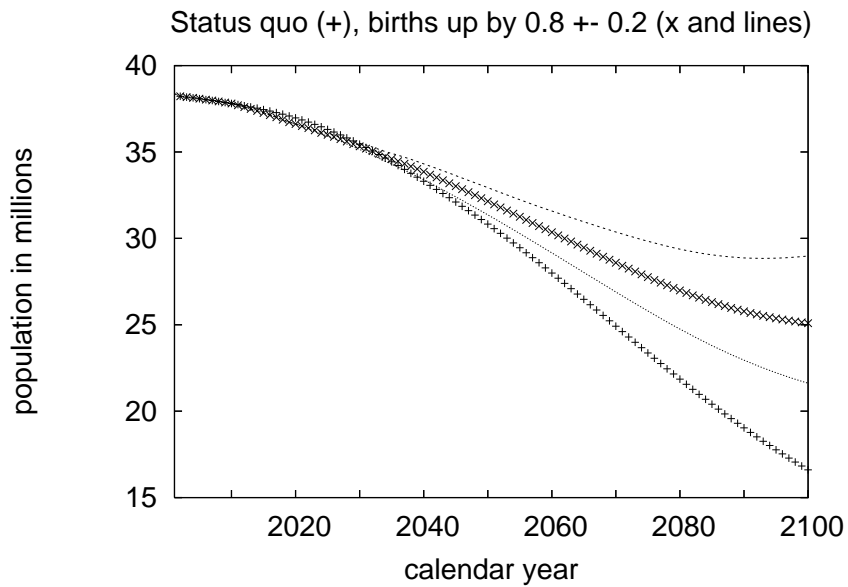


Figure 4: Help from increased births. The lowest curve uses the present birth rate, the higher curves assume more or less strong increases of births in the future.

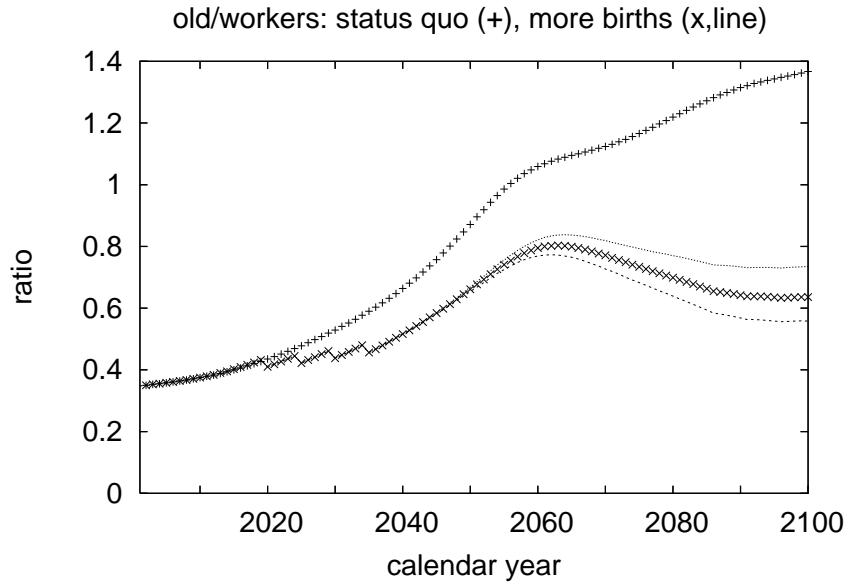


Figure 5: Help from increased births and increased retirement age. Same simulation as in the previous figure; the rise of retirement age from 63 to 67 does not affect the total population shown in the previous figure.

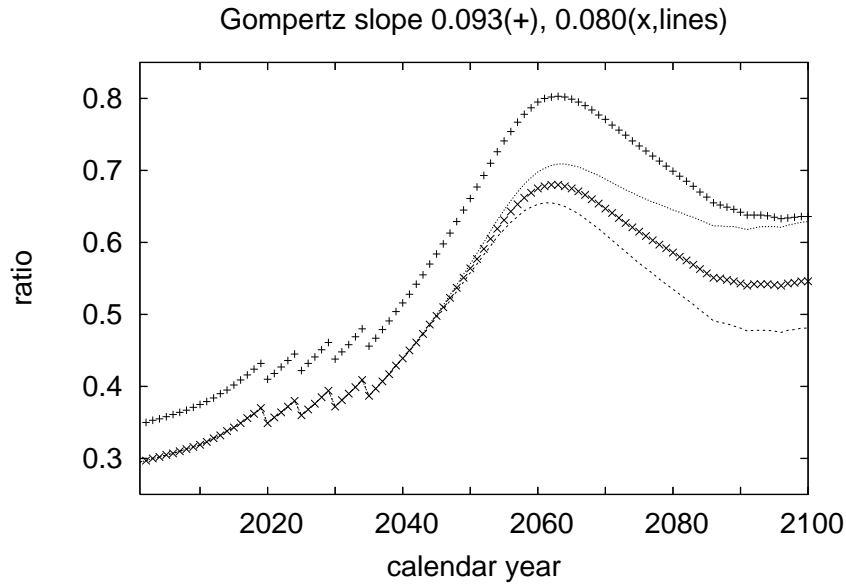


Figure 6: Ratio of old to working-age people for different Gompertz slopes 0.093 (plus signs, Germany) and 0.08 (other curves, Polish men).

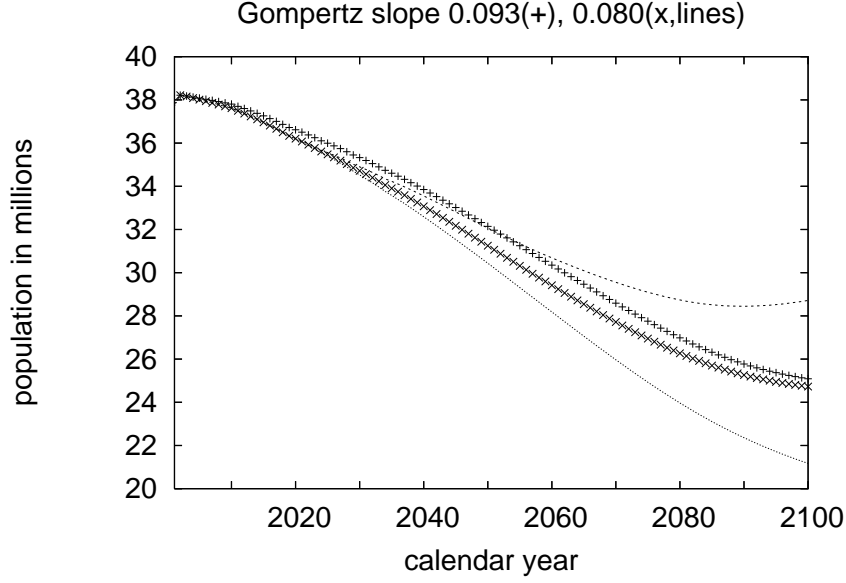


Figure 7: Populations for different Gompertz slopes, same simulations as in previous figure.

the past this emigration was negligibly small, about 0.04 percent per year. The lowest curve in Fig.4 shows the resulting decay of the total population.

To get more optimistic curves, the retirement age was assumed to increase from 63 by one year and the births by 0.2 in the years 2020, 2025, 2030 and 2035; increase in retirement age alone did not help much. These assumptions give the x symbols in Fig.4. The two lines on both sides of the x curve correspond to changes 0.25 (higher line) and 0.15 (lower line) in the births and indicate the order of magnitude of the extrapolation errors. Fig.5 shows the ratios of people in retirement age to people in working age, corresponding to the same simulations as in Fig.4.

In the above simulations the Gompertz slope was taken as $b = 0.093$, with the mortality function increasing for adults as $\exp(bx)$ with increasing age x , as in [1, 2]. The actual Polish value is near 0.08 similar to Algeria[3]. Using $b = 0.08$ instead of 0.093 we get Figs.6 and 7, which overlap with the results of Figs.4 and 5.

Thus enhanced birth rates as simulated here and massive immigration as simulated for countries like Germany [1, 4] could reduce the shrinking of the population and the burden of the working population to support the retired people. That burden would also be alleviated by increasing retirement age; German parliament adopted in 2006 a law regulating these future increases. France recently increased the births from 1.7 to 1.9 within a decade. Other countries in the European Union, like Bulgaria, Romania or the three Baltic states, may be in a situation similar to Poland.

Simulations like these took less than a second each, in contrast to more sophisticated methods [7], and readers can change parameters to check for the

effects of different assumptions. Countries corresponding to these simulations still have time to adjust to the future problems of the demographic change. The ageing problems seem to become very serious after the year 2050.

K. Kułakowski kindly provided the empirical Polish data from www.stat.gov.pl used in this work, and commented on the manuscript.

Appendix:

The simulations calculate the age distribution of the population in one year from that in the preceding year, neglecting possible correlations between a mother and her daughters. For extrapolations over a few generations this approximation should be good enough. A complete Fortran program is given in [4, 5].

Women give birth from ages 21 and 40, of daughters with half of the birth number given in the text, spread evenly over these 20 years. Sons represent the other half and can be neglected. The population increases by immigration or decreases by emigration, affecting equally all ages from 6 to 40. The mortality is assumed as $7b \exp[b(x - X)]$, giving a survival probability $S(x)$ from birth to age x as $S = \exp(-7 \exp(-bX)(\exp(bx) - 1))$. Thus after births and migration have been dealt with, the population $P(x)$ at age x is calculated from $P(x) = P(x - 1)S(x)/S(x - 1)$. Here the Gompertz slope b is assumed to increase over 150 years from $b = 0.07$ to $b = 0.093$ (or 0.08) until the year 1971, and then to stay constant at this maximum value. The characteristic age X , in contrast, is assumed to stay constant at 103 until 1971, and thereafter to increase by 0.15 each year. This change of trends around 1971 was seen in some empirical studies of the last years.

References

- [1] D. Stauffer, 2002, *Exp. Gerontology*, 37, 1131.
- [2] J.S. Sá Martins, D. Stauffer, 2004, *Ingenierias* (Univ.Nuevo Leon, Mexico) 7, 35 (Jan-Mar issue).
- [3] L. Zekri, D. Stauffer, 2005, *AIP Conference Proceedings* 779, 69.
- [4] D. Stauffer, S. Moss de Oliveira, P.M.C. de Oliveira, J.S. Sá Martins, *Biology, Sociology, Geology by Computational Physicists*. Amsterdam: Elsevier 2006.
- [5] M. A. Sumour, A. H. El-Astal, M. M. Shabat and M. A. Radwan, 2007, *Int. J. Mod. Phys. C* 18, issue 11.
- [6] E. Bomsdorf, 2004, *Exp. Gerontology* 39, 159.
- [7] K. Bońkowska, S. Szymczak and C. Cebart, 2006, *Int. J. Mod. Phys. C* 17, 1477.